Scandinavian Journal of Urology and Nephrology

ISSN: 0036-5599 (Print) 1651-2065 (Online) Journal homepage: http://www.tandfonline.com/loi/isju19

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To cite this article: Ali Gunes, Murat Yahya Ugras, Ugur Yilmaz, Can Baydinc & Ahmet Soylu (2003) Percutaneous nephrolithotomy for pediatric stone diseaseOur experience with adult-sized equipment, Scandinavian Journal of Urology and Nephrology, 37:6, 477-481, DOI: 10.1080/00365590310001755

To link to this article: http://dx.doi.org/10.1080/00365590310001755

Published online: 09 Jul 2009.

Taylor & Francis healthsciences

Percutaneous Nephrolithotomy for Pediatric Stone Disease

Our Experience with Adult-sized Equipment

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(Submitted October 28, 2002. Accepted for publication March 31, 2003)

Scand J Urol Nephrol 37: 477–481; 2003

Objective: We evaluated the outcomes and complications of percutaneous nephrolithotomy (PNL) operations performed in pediatric patients using adult-sized surgical equipment at our center.
Material and Methods: The medical and surgical records of 23 children who underwent a total of 25 PNL operations using 24 or 26 F rigid nephroscopes were evaluated retrospectively. The following aspects were considered: stone burden; duration of surgery and complications; details concerning recovery, success, residual fragments and auxiliary procedures; and follow-up details.
Results: The success rate of a single PNL session was 70.8%; with the use of auxiliary procedures this was increased to 91.6%. Perioperative and early postoperative complications were excessive bleeding and transfusion in two patients, hydro-pneumothorax in one, perforation of the collecting system in three and urinoma in one. Complications were more common in children aged <7 years or with staghorn stones. The mean time to catheter removal was 3.4 days and the mean hospitalization time was 4.8 days. Idiopathic hypercalciuria, hypocitraturia, cystinuria and hyperoxaluria were diagnosed in two, two, one and three patients, respectively.
Conclusion: Performing PNL with adult-sized equipment is associated with significant complications in children aged <7 years or with staghorn stones. This treatment should not be considered in routine clinical practice. As all stone-removal methods are associated with complications, PNL should be used only if other methods fail or are unavailable.

Key words: pediatric, percutaneous nephrolithotomy, stone disease.

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Percutaneous nephrolithotomy (PNL) has well-established efficacy and safety in adult patients with renal stone disease, and there are increasing number of reports investigating the same parameters in pediatric patients.

Since its introduction for clinical use in 1976, PNL has undergone some changes in terms of indications, equipment and surgical technique. Indications have been widened to include older and younger patients, neurologically disabled patients and difficult stones such as staghorn stones. The equipment has been replaced by flexible, small-caliber optic devices, less invasive dilators and safer stone disintegrators. The technique has been changed to involve higher intercostal puncture, single-session dilation and extraction, mini-perc with small-caliber nephrostomy tracts, endopyelotomy and tubeless PNL. These rapid changes have led to studies of efficacy and safety being performed as routine investigations to evaluate effects and outcomes.

Since the first pediatric PNL cases, this operation has been performed in children with stone disease in an increasing number of clinics. The above-mentioned changes have taken place in this group of PNL operations, although to a lesser extent.

In this study, we present our initial experience of PNL in children with renal stone disease performed using adult-sized surgical equipment.

MATERIAL AND METHODS

Between January 2000 and May 2002, we performed 25 PNL operations for 24 renal units in 23 pediatric patients: 12 boys (mean age 12.3 years; age range 27 months to 16 years) and 11 girls (mean age 9.4 years; age range 5–16 years). Of these, one had bilateral, 11 had multiple, three had semistaghorn (involving the renal pelvis and at least one infundibulum) and eight had solitary renal stones. The mean stone burden was 3.42 cm^2 (1.2–14.8 cm^2). Presenting symptoms were

 ISSN 0036–5599
DOI 10.1080/00365590310001755

pain in 14 patients, hematuria in six, nausea and vomiting in two and infection in seven. One patient was diagnosed incidentally while being examined for bowel symptoms. At i.v. urography (IU), one of the patients had a duplicated pelvis and ureter, three had duplicated pelves and four had infundibular stenosis. Four of the kidneys were obstructed by the stone at the time of diagnosis. Spiral CT and renal scintigraphy with diuretic renograms were obtained for three children with a suspicion of ureteropelvic junction obstruction (UPJO), which proved to be positive in one.

Indications for PNL were a large stone burden in eight patients, an anomalous kidney anatomy unsuitable for extracorporeal shock-wave lithotripsy (ESWL) in nine, failed ESWL in five and failed prior PNL in one of the renal units. In two children aged 27 months and 5 years, respectively with a stone burden and anatomy suitable for ESWL, the parents did not want to take the risk of multiple sessions of anesthesia and steinstrasse and so we decided to perform PNL.

All of the operations were performed using general anesthesia and an i.v. cephalosporin for antibiotic cover. The operation room was heated to 23–25°C, and electrically heated operation blankets were placed under the patient. After induction of anesthesia, ureteral catheters (4–6 F) were inserted in the ipsilateral ureter and kidney. We did not perform a retrograde study routinely in order not to blur the vision of the stone at fluoroscopy. Patients were placed in a prone position and using biplanar fluoroscopy guidance a puncture was made in the most suitable kidney site with an 18 G percutaneous access needle and guidewire. The tract was dilated to the proper size (24–30 F) with an Amplatz semi-rigid dilator and a renal sheath was placed. A 24 or 26 F rigid nephroscope was used for working. Sterile saline (35–36°C) was used for irrigation. Using video guidance and fluoroscopy, the stones were found and grasped with forceps. If the stone diameter was not suitable for grasping, a pneumatic lithotripter was used for disintegration. Small stone particles were aspirated out of the kidney. Narrow infundibulae were dilated to 14–18 F with Amplatz dilators in three cases. After controlling the collecting system for residual fragments using direct vision and fluoroscopy, a reentry nephrostomy tube (12–16 F) was placed; an antegrade radiopaque study was performed routinely to check for perforations, infundibular stenoses and correct positioning of the nephrostomy tube. Indwelling ureter catheters were left in place at the end of the procedure.

Ureteral catheters were usually removed on the first postoperative day. A plain roentgenogram was obtained and an antegrade study performed and, if no drainage problem was encountered, the nephrostomy tube was completely removed. The patients were then discharged and asked to return for an ultrasound control after 1 week and for an IU evaluation in the third postoperative month.

Success was determined as being completely stone-free or having clinically insignificant residual fragments (CIRFs) on plain roentgenograms obtained during the early postoperative days. A CIRF was determined as a stone fragment with a largest diameter of $\leq$3 mm.

Postoperative problems were noted, as well as auxiliary procedures performed for residual stones and the results of metabolic evaluation.

RESULTS

After one session of PNL, 15 renal units were completely stone-free and two had CIRFs, giving a success rate of 70.8% (17/24). Following auxiliary procedures, five additional kidneys were rendered stone-free or with CIRFs only, increasing the success rate to 91.6% (22/24) (Table I).

The mean operative time was 122 min, including ureteral stenting and repositioning.

Only one puncture was made in 22 renal units: 12 to the mid calyces, five to the lower calyces and five directly to the pelvis. More than one puncture was necessary for two kidneys with multiple stones: lower and upper calyx entry in one and lower and mid calyx entry in the other.

In a 7-year-old patient who underwent bilateral simultaneous PNL for bilateral stones, a stone-free state was achieved in the left kidney, but a residual fragment remained in the right. He underwent two sessions of ESWL to the right side 1 week after PNL, which led to fragmentation of the stone. One month later, only a CIRF of the stone had not passed spontaneously.

One patient with ipsilateral UPJO underwent endopyelotomy in the same session, resulting in anatomical correction of the obstruction on IU and improvement of emptying on diuretic renography, both being achieved 3 months postoperatively.

Table I. *Details of unsuccessful results of single-session PNL*

Age (years)	Initial stone burden (cm^2)	Residual stone burden (cm^2)	Auxiliary procedure	Result
5	2.4	0.3	SWL	RES
7	5.1	0.4	SWL	CIRF
9	6.3	1.8	Re-PNL	SF
14	6.0	0.4	SWL	SF
15	4.3	0.7	SWL	SF
15	2.5	0.6	–	RES
16	6.3	0.9	SWL + URS	SF

Re-PNL = Second-look PNL; URS = ureterorenoscopy; RES = residual fragment; SF = stone-free.

Of the three patients in whom a narrow infundibulum was dilated, none had a diameter of the dilated area of <3 mm at 3-month control IU.

The total complication rate was 30.4% (7/23), and 71.4% (5/7) of the complications occurred in patients aged $\leq$7 years.

The mean decrease in hemoglobin level was 2.0 mg/ml and there was a need for blood transfusion in 8.7% (2/23) of the patients. Of these two patients, one was the boy with bilateral stones and the other was a boy whose surgery was terminated due to excessive bleeding. They both recovered without any other complications.

Hydro-pneumothorax was diagnosed in a 14-year-old boy in the operating room while he recovered from the anesthetic and a chest tube was placed immediately. No other problem was encountered during the early postoperative period and, after removing the chest tube, he was discharged on Day 5.

In a 5-year-old girl, a 6-mm residual fragment caused obstruction of the upper ureter just after removal of the nephrostomy tube, and urine collection in the perirenal area was revealed by ultrasound examination. Immediate stenting of the ureter was performed and, with antibiotic coverage, the collection resolved uneventfully. This patient did not attend for ESWL for her residual fragment and was considered an unsuccessful case.

Three renal pelves were revealed to have perforations in the antegrade study performed at the end of the procedure. One of them had a stone fragment located outside the kidney after the procedure. In these patients, ureteral stents were retained for longer periods and nephrostomy tubes were not withdrawn until repeat antegrade studies proved that no further urine leakage existed. The first repeat study was performed on the fifth postoperative day.

Body temperature records were available in 19 patients, the mean temperature being 36.4°C before and 35.3°C at the end of the procedure, indicating a decrease of 1.1°C during the operation. All of the patients reached normal body temperature levels within 3 h postoperatively.

Three patients showed a significant rise in body temperature (>38°C) in the early days following surgery; all had identifiable microorganisms in their urine and were treated with appropriate antibiotic therapy according to the urine culture. No evidence of bacteremia was encountered.

Ureteral stents were removed on average 1.2 days postoperatively, except for three children with renal pelvis perforation and one who underwent endopyelotomy in the same session and had an internal stent for 6 weeks.

Nephrostomy tubes were removed on average 3.4 days postoperatively, with the exception of a girl with a residual stone who underwent a second-look procedure after 2 weeks, during which time the nephrostomy tube was retained.

Patients were hospitalized for a mean of 4.8 days.

Metabolic evaluation revealed idiopathic hypercalciuria in two patients, hyperoxaluria in three, cystinuria in one and hypocitraturia in two.

DISCUSSION

With improvements in equipment technology, open surgical procedures are constantly being replaced by endosurgical counterparts, especially during the last two decades (1). A similar trend can be observed in pediatric patients with stone disease, although to a lesser extent (2). This subgroup of stone patients have some specific features which make their disease a slightly different entity. As children with stones are at risk for longer periods than adults, they have a higher probability of recurrence and, thus, of undergoing more interventions (3). This fact brings with it the necessity of behaving as minimally invasively as possible whilst treating pediatric stone patients. Another point is that, as there may be an underlying urological cause in these patients, therapeutic intervention should be directed to cure this condition, as well as to remove the stone.

Today, ESWL is considered to be the first line of treatment in the absence of obstructive uropathy in children (4). It represents a successful and safe modality of treatment for the stone but not the cause in children (5–8). Also, ESWL is associated with some discrepancies resulting from the use of different lithotripters, factors effecting clearance of fragments following the procedure and differences between animal studies and clinical investigations regarding its safety (5).

Surgical interventions are the second line of treatment if ESWL is contraindicated. Among a variety of surgical approaches, PNL offers a safe and effective choice for children. It has success rates of 66–100% in children, varying primarily with the definition of success and the learning curve (2, 9–15). Our rate of success is in concordance with those reported in the literature, although a smaller size is used to define a CIRF. There is agreement in the literature regarding the stone fragment size that does not cause serious problems and thus can be considered a CIRF in adults; however, there is still debate in this regard in pediatric patients (16–18). Also, we have to consider the debate on using the term CIRF, regarding the interobserver variability of the fragment size according to the diagnostic method used and clinically significant interpatient variability (19).

Staghorn stones seem to remain troublesome when

PNL is considered as a treatment option (20, 21). In our series, two of the three patients with semistaghorn stones had fragments that needed further procedures. In spite of our therapeutic efforts, one of them had a residual fragment that could not be removed. Renal pelvis perforations occurred in two of the patients with staghorn stones who needed longer stenting. One of them had a fragment that had fallen into the retroperitoneal area through the perforation. These conditions caused significant stress for both the children and their parents, reminding the authors that anatrophic nephrolithotomy may have been a better approach for these patients (22).

Anatomical abnormalities such as primary and secondary UPJO and infundibular stenosis can be corrected by combining PNL with other endourological procedures (23–25). Although open pyeloplasty remains the gold standard for UPJO, endopyelotomy achieves similar success rates with a lower morbidity and thus can be a good treatment alternative. In our series, one patient with UPJO and three with infundibular narrowing were treated with endosurgical procedures and an improvement in drainage was observed in all of them.

The age and stone burden distributions of the patients with complications are shown in Table II. It is obvious that patients with semistaghorn stones and patients aged $\leq$7 years are more prone to some severe complications when adult-sized equipment is used. Although it is easier to retrieve stone fragments through a large-bore channel than through tiny pediatric instruments, nephrostomy sheaths of 24–30 F may be troublesome in younger children. Desai et al. (13) recommended a dilatation no larger than 18.5–21 F in children aged <8 years, indicating that wider dilatations cause a threefold decrease in hemoglobin levels. Our experience reinforces their results, and we also recommend using smaller equipment in children aged <7 years whenever possible.

A decrease in the hemoglobin level during PNL is of particular importance because of hemodilution, and significant hemorrhage as observed by the surgeon may be a more reliable indication for transfusion. Equipment size, stone burden and operative time are suggested determinants of blood loss in pediatric PNL (10, 13, 15). The number of punctures has also been mentioned as a significant cause of bleeding in these patients (20). With the use of large-caliber nephrostomy sheaths, two of our patients (8.6%) had bleeding that necessitated transfusion.

Table II. *The age and stone burden distributions of the patients with complications*

Complication	Age (years)	Stone burden (cm^2)	Renal sheath diameter (F)
CS perforation	5	4.0	26
CS perforation	16	6.3 (S)	30
CS perforation	2.5	1.5	24
Urinoma	5	2.4	24
Hydro-pneumothorax	14	5.3 (S)	30
Transfusion	7	5.1 (S)	26
Transfusion	6	3.3	26

CS = collecting system; S = semistaghorn stone.

Hypothermia is a complication that correlates with the surgical time as well as with the duration of preoperative preparation and induction of anesthesia (11, 26). Every measure was taken to prevent heat loss in our series, namely heating the irrigation fluid and operation room, isolating the patient's skin from fluids and placing an electrically heated operation blanket under the body. Despite these precautions, there was a significant decrease in body temperature, which returned to preoperative baseline levels postoperatively.

Hydro-pneumothorax is a rare but major complication associated with PNL, especially if the puncture is made above the 11th rib or between the 11th and 12th ribs (27, 28). Reports regarding this complication have primarily involved adult series, although there is no reason why it should not occur in children. One of our patients (4.3%) had hydro-pneumothorax, which was probably due to puncture between the 11th and 12th ribs and misplacement of Amplatz dilators. After taking appropriate measures, this patient healed without any further problems.

In series comparing open and percutaneous approaches for kidney stones (2, 29), PNL was found to be associated with a shorter hospital stay and a decreased period of convalescence. Our period of hospitalization was also shorter for PNL, although a statistical comparison was not performed.

CONCLUSION

PNL is a good alternative for treatment of pediatric stone disease. It also represents an effective method for treating some of the underlying pathological conditions. In patients who are unsuitable for more conservative treatments, or in whom these methods fail, PNL can be considered the next line of treatment. In our series, a higher incidence of complications was observed in younger patients or those with staghorn stones, similar success rates were achieved as in adults and no significant morbidity was noted at follow-up. Based on these data, we conclude that PNL using adult-sized equipment is not a safe method of treatment in children aged <7 years, and should not therefore be performed in regular clinical practice. In older children, the method can be applied with caution if other methods fail or are unavailable.

REFERENCES

1. Clayman VR, McDougall EM, Nakada YS. Endourology of the upper urinary tract: percutaneous renal and ureteral procedures. In: Walsh RC, Retik AB, Vaughan AB, Wein AJ, eds. Campbell's urology, 7th edn. London: Saunders, 1998: 2789–874.
2. Mor Y, Elmasry YET, Kellett MJ, Duffy PG. The role of percutaneous nephrolithotomy in the management of pediatric renal calculi. J Urol 1997; 158: 1319–21.
3. Menon M, Parulkar BG, Drach GW. Urinary lithiasis: etiology, diagnosis, and medical treatment. In: Walsh RC, Retik AB, Vaughan AB, Wein AJ, eds. Campbell's urology, 7th edn. London: Saunders, 1998: 2659–749.
4. Riedmiller H, Androulakakis P, Beurton D, Kocvara R, Gerharz E. EAU guidelines on paediatric urology. Eur Urol 2001; 40: 589–99.
5. Esen T, Krautschick A, Alken P. Treatment update on pediatric urolithiasis. World J Urol 1997; 15: 195–202.
6. Picramenos D, Deliveliotis C, Alexopoulou K, et al. Extracorporeal lithotripsy for renal stones in children. Urol Int 1996; 56: 86–9.
7. Nazli O, Cal C, Ozyurt C, Gunaydin G, et al. Results of extracorporeal shock wave lithotripsy in the pediatric age group. Eur Urol 1998; 33: 333–6.
8. Van Horn AC, Hollander JB, Kass EJ. First and second generation lithotripsy in children: results, comparison and follow-up. J Urol 1996; 153: 1969–72.
9. Woodside JR, Stevens GF, Stark GL, et al. Percutaneous stone removal in children. J Urol 1985; 134: 1166–70.
10. Callaway TW, Lingardh G, Basata S, Sylven M. Percutaneous nephrolithotomy in children. J Urol 1992; 148: 1067–8.
11. Al-Shammari AM, Al-Otaibi K, Leonard MP, Hosking DH. Percutaneous nephrolithotomy in the pediatric population. J Urol 1999; 162: 1721–4.
12. Badawy H, Salama A, Eissa M, et al. Percutaneous management of renal calculi: experience with percutaneous nephrolithotomy in 60 children. J Urol 1999; 162: 1710–3.
13. Desai M, Ridhorkar V, Patel S, et al. Pediatric percutaneous nephrolithotomy: assessing impact of technical innovations on safety and efficacy. J Endourol 1999; 13: 359–64.
14. Sahin A, Tekgül S, Erdem E, et al. Percutaneous nephrolithotomy in older children. J Pediatr Surg 2000; 35: 1336–8.
15. Zeren S, Satar N, Bayazit Y, et al. Percutaneous nephrolithotomy in the management of pediatric renal calculi. J Endourol 2002; 16: 75–8.
16. Streem BS, Yost A, Mascha E. Clinical implications of clinically insignificant stone fragments after extracorporeal shock wave lithotripsy. J Urol 1996; 155: 1186–9.
17. Zanetti G, Seveso M, Montarini E, et al. Renal stone fragments following shock wave lithotripsy. J Urol 1997; 158: 352–5.
18. Docimo SG. Pediatric endourology—coming into focus [Editorial]. J Urol 1999; 162: 1731–2.
19. Khaitan A, Gupta NP, Hemal AK, et al. Post-SWL clinically insignificant residual stones: reality or myth? Urology 2002; 59: 20–4.
20. Martin X, Tajra LC, Gelet A, et al. Complete staghorn stones: percutaneous approach using one or multiple percutaneous accesses. J Endourol 1999; 13: 367–8.
21. Martin X, Tolley D, Gallucci M, Alken P. The difficult stone case: definition and management. Eur Urol 2001; 40: 1–9.
22. Assimos DG, Wrenn JJ, Harrison LH, et al. A comparison of anathrophic nephrolithotomy and percutaneous nephrolithotomy with and without extracorporeal shock wave lithotripsy for management of patients with staghorn calculi. J Urol 1991; 145: 710–4.
23. Schenkman EM, Tarry WF. Comparison of percutaneous endopyelotomy with open pyeloplasty for pediatric ureteropelvic junction obstruction. J Urol 1998; 59: 1013–5.
24. Tan HL, Najmaldin A, Webb DR. Endopyelotomy for pelvic-ureteric junction obstruction in children. Eur Urol 1993; 24: 84.
25. Faerber GJ, Ritchey ML, Bloom DA. Percutaneous endopyelotomy in infants and young children after failed pyeloplasty. J Urol 1995; 154: 1495–7.
26. Roberts S, Bolton DM, Stoller ML. Hypothermia associated with percutaneous nephrolithotomy. Urology 1994; 44: 832–5.
27. Finelli A, Honey RJ. Thoracoscopy-assisted high intercostal percutaneous renal access. J Endourol 2001; 15: 581–4.
28. Kekre NS, Gopalakrishnan GG, Gupta GG, et al. Supracostal approach in percutaneous nephrolithotomy: experience with 102 cases. J Endourol 2001; 5: 789–91.
29. Boddy SM, Kellett MJ, Fletcher MS, Ransley PG, Paris AM, Whitfield HN, et al. Extracorporeal shock wave lithotripsy and percutaneous nephrolithotomy in children. J Pediatr Surg 1987; 22: 223.